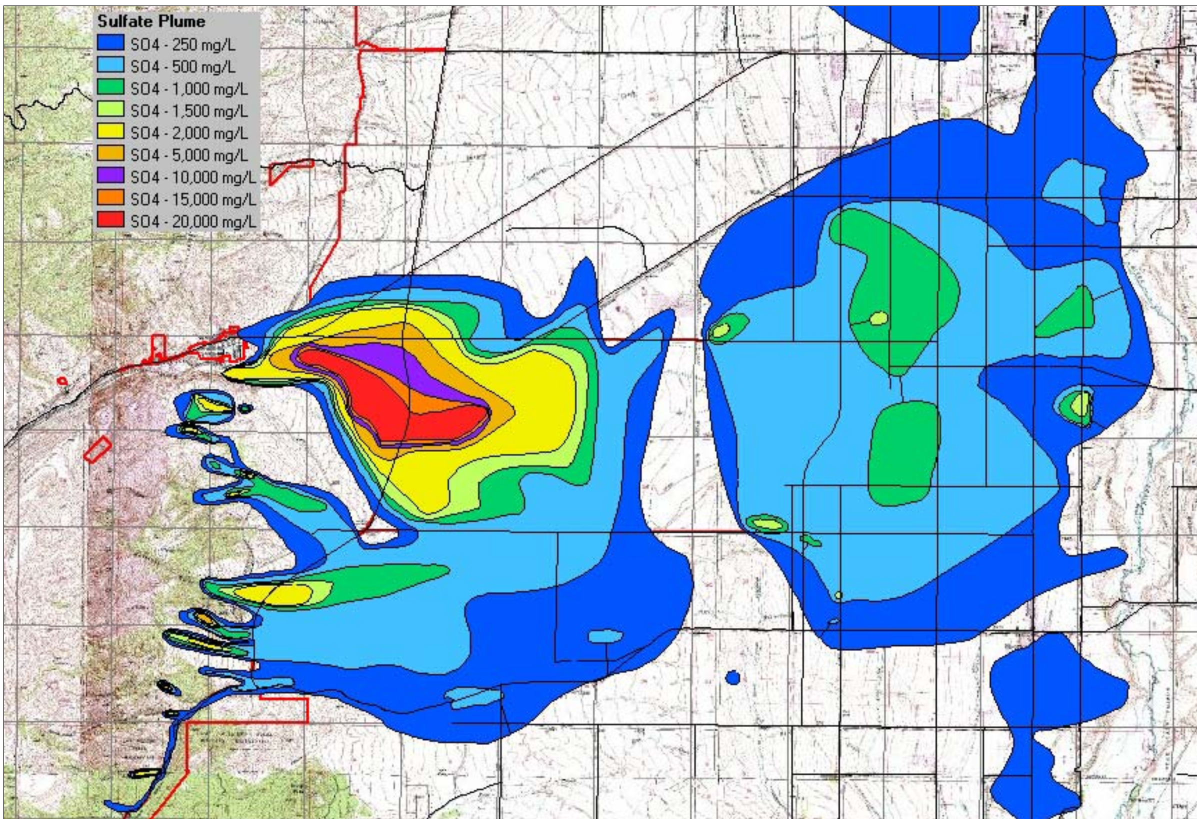
KENNECOTT UTAH COPPER CORPORATION

FINAL DESIGN FOR REMEDIAL ACTION AT SOUTH FACILITIES GROUNDWATER



Prepared by:

Kennecott
Utah Copper

December 2002

Table of Contents

List of Tables

List of Figures

1.0 INTRODUCTION

1.1 Purpose of Final Design

Kennecott Utah Copper Corporation (KUCC) has prepared a Final Remedial Design to address groundwater contamination at KUCC's South Facilities in accordance with the U.S. Environmental Protection Agency's Record of Decision dated December 13, 2000. In addition, many elements of the Final Design and Remedial Action address KUCC's obligations under the Natural Resource Damage (NRD) settlement with the State of Utah from 1995. The Final Remedial Design addresses the size, scope and character of the Remedial Action. Specifically, the Final Design Report:

- describes the problems to be addressed;
- identifies the technical requirements to complete a successful remedial action;
- establishes performance-based criteria for the components of the remedy, emphasizing the period during which the Bingham Canyon mine continues to operate;
- reports the results of design investigations and support activities needed to finalize engineering plans;
- presents the engineering plans and specifications that will implement the performance criteria;
- documents monitoring programs that will be implemented during and following remedial actions;
- provides schedules for implementing the remedial action;
- presents a Preliminary Design-level presentation of alternatives for post-mining water management of the remediation water described in this report.

The *Final Design*, prepared as the engineering-design document for the project, includes the following elements:

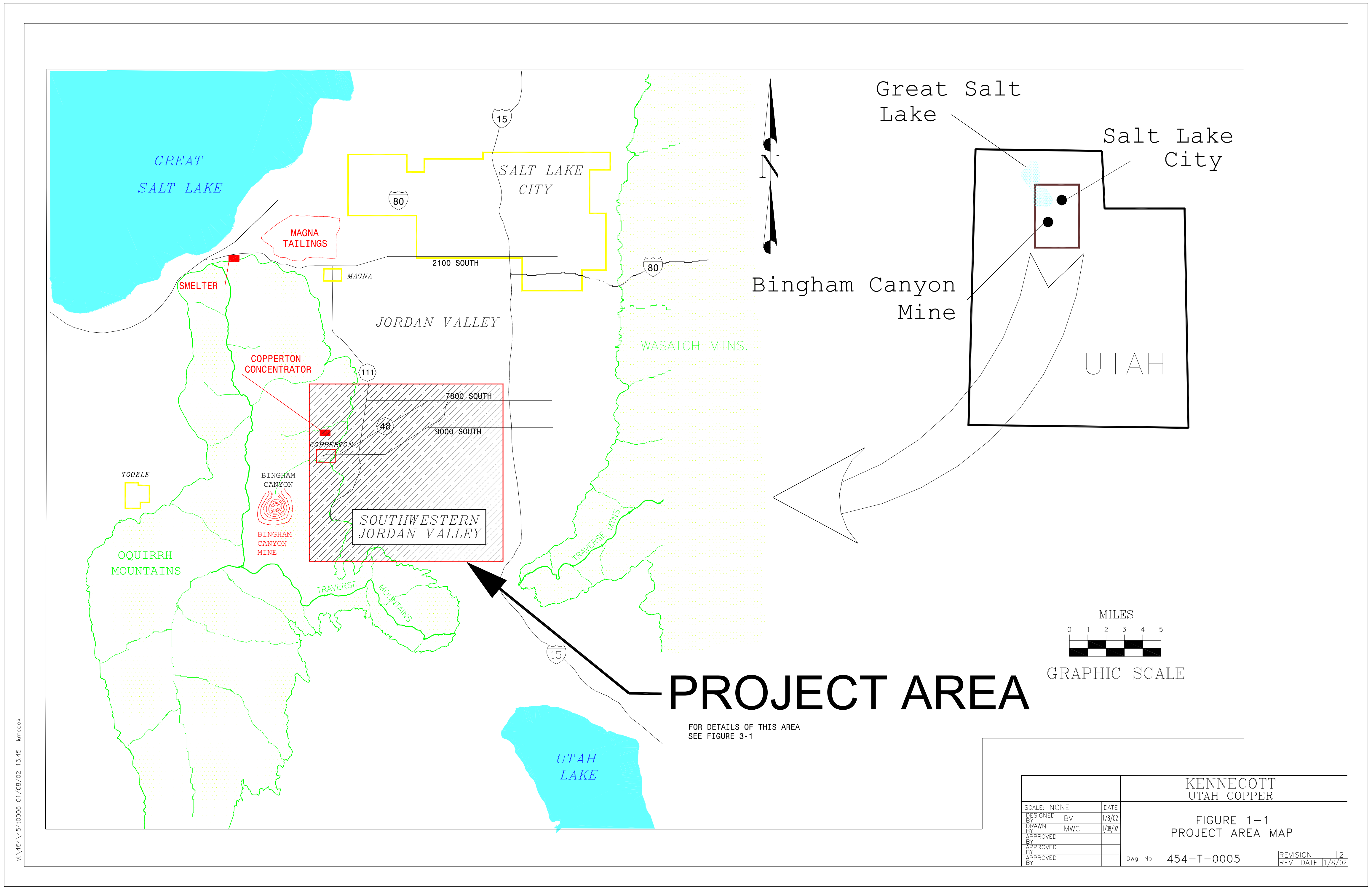
- performance and, as appropriate, design criteria;
- project delivery strategy;
- results of treatability studies and additional field sampling;
- plans, drawings and sketches;
- description of required performance objectives and/or specifications;
- the construction schedule for Remedial Action.

1.2 Site Background and Summary of Site Conditions and Risks

1.2.1 Study Area

The southwest Jordan Valley (SWJV) extends from the KUCC waste rock disposal areas on the eastern edge of the Oquirrh Mountains to the Jordan River. The foothills of the Traverse Mountains bound it on the south; the northern boundary is at approximately 7800 South Street. Figure 1-1 shows the project area.

Figure 1-1 Project Area Map



1.2.2 Site Description

The Bingham Canyon mine is located on the western edge of the SWJV in the Oquirrh Mountains. The open-pit mine covers 1,900 acres and is over one-half mile deep. More than five billion tons of rock have been removed from the pit, resulting in the production of more than 15 million tons of copper and other metals. Waste rock from the mine is placed along the east, west and north sides of the pit, where it receives meteoric precipitation that results in some natural leaching. Prior to 2000, the waste rock was artificially leached with recycled acidic water. The active leaching circuit was phased out beginning in 1999 and finally discontinued on September 29, 2000.

1.2.3 Summary of Site Characteristics and Risks

This section summarizes the regional and site-specific geography, geology and hydrogeology as interpreted from previous site characterization studies. The site description and technical background of the problems are provided in very great detail in the Remedial Investigation (KUC, 1998a) and Feasibility Study (KUC, 1998b) and in the Remedial Design Work Plan (KUC, 2001a). For the Final Design the background material will be significantly abbreviated so that the design elements themselves can be succinctly presented. The following material is adapted, much of it verbatim, from the EPA/UDEQ document "Southwestern Jordan Valley Groundwater Plumes Proposed Plan", issued in August 2000 in conjunction with public comment period on the proposed groundwater cleanup plan or the Record of Decision for the same project. Readers requiring more detail should consult the earlier technical documents that specifically describe the RI/FS programs. Appendix B to this report updates the status and results of groundwater flow and transport modeling since the RI/FS. Appendix C presents the results of the geochemical studies conducted during the Remedial Design phase. Since the completion of the RI/FS, a baseline water level and chemistry report has been completed that documents the nature and extent of groundwater contamination in 2001 and 2002. This report, attached as Appendix D, will be used as the baseline to evaluate the success of the remediation program.

There has been mining in the Oquirrh Mountains since the 1870s. Historical mining processes, including past operations of KUCC, resulted in groundwater contamination. Natural meteoric infiltration and pumped mine-waters reacted with sulfide-bearing waste rock to generate effluents that were high in total dissolved solids, including sulfate. In portions of the system, the waters were acidic and leached metals. In addition to generalized seepage, the Large Bingham Reservoir, the Old Evaporation Ponds, and other collection systems, built to contain such waters, leaked over many years. In the lower part of the valley, non-KUCC mining sources, such as irrigation canals and the ARCO tailings impoundment may also have contributed to elevated concentrations of some constituents.

Intermittent and ephemeral surface waters and groundwater flow from the Oquirrh Mountains toward the Jordan River. The flow of mine-impacted effluents in the ground-water flow system produced plumes of contaminated groundwater within the aquifer in the Southwestern Jordan Valley. The Remedial Investigation (KUC, 1998a) showed that there are about 171,000 acre-feet of groundwater that exceed appropriate water-quality criteria. The U.S. Environmental Protection Agency (EPA) and the Utah Department of Environmental Quality (DEQ) have determined that the ground-water plumes containing sulfate concentrations greater than 1500 mg/L sulfate or acid constitute a risk to human health and the environment that requires remedial actions.

The nature and extent of contamination of the groundwater depend upon location:

- In Zone A, immediately down-gradient of the Bingham Reservoir and the waste-rock piles, the groundwater system includes an acidic plume, surrounded by a partially to fully neutralized zone of high-sulfate waters. Within the high-sulfate acidic plume, there are a variety of heavy metals in solution at concentrations that exceed drinking-water standards, in some places by a factor of one hundred or more.

- In Zone B, located at and down-gradient from the old KUCC Evaporation Ponds, the groundwater contaminant of concern is sulfate, which is present in Zone B at concentrations that average less than 1,500 mg/L but above the State Drinking-Water Primary Standard of 500 mg/L.

Of major concern is the proximity of mining-affected groundwaters, especially Zone A, to municipal well fields of West Jordan and Riverton. Further off-site migration of contaminated groundwaters must be controlled in order to protect these public water-supply systems.

EPA, acting on data developed by KUCC in the Remedial Investigation, defined Remedial Action Objectives for corrective actions with respect to CERCLA in Zone A:

1. Minimize or remove the potential for human risk (by means of ingestion) by limiting exposure to groundwater containing chemicals of concern exceeding risk based concentrations or drinking water Maximum Contaminant Levels;
2. Minimize or remove the potential for environmental risk (by means of flow of groundwater to the Jordan River) to receptors of concern;
3. Contain the acid plume and keep it from expanding;
4. Remediate the aquifer over the long term.

Potential response actions were described and evaluated in the Feasibility Study (KUC, 1998b), which proposed a preferred remedy, discussed in Section 1.3 below.

In addition to the CERCLA response for Zone A that is the principal focus of this Remedial Design, KUCC is coordinating its Zone A activities with remedial actions in Zone B that are intended to resolve Natural Resource Damage Claim issues in the Zone B plume. Both agencies (EPA and UDEQ) and also KUCC understand that the cleanup of the two zones is linked by the historical nexus of origins of the plumes and by the hydrogeology of the groundwater flow systems. The principal objective of the Natural Resource Damage Claim – to "restore, replace or acquire the equivalent" of the damaged ground-water resource - is addressed in a separate settlement between the State of Utah, acting through its Natural Resource Trustee, and Kennecott. Portions of that settlement that overlap the scope of the CERCLA remedial action include:

1. Completing the CERCLA actions;
2. Extracting contaminated groundwater from the acid plume at a minimum rolling average of 400 acre-feet per year to remove contaminant mass and contain the plume;

3. Completing identified source controls in order to comply with KUCC's ground-water discharge permit;
4. Creating a trust fund to be used to "restore, replace or acquire the equivalent" of the lost groundwater to the benefit of the public in the affected area.
5. Producing 3500 acre-ft per year of drinking water from the Zone A sulfate plume that will be delivered to the affected communities.

1.3 Description of Selected CERCLA Remedy

To ensure compatibility, this section is taken verbatim from the U.S. Environmental Protection Agency's Record of Decision (EPA, 2000).

"The selected remedy involves treatment and containment of contaminated groundwater plumes. The principal threats, which caused the groundwater contamination, have been addressed in previous actions or are contained under provisions of a Utah Groundwater Protection Permit.

The selected remedy contains the following elements:

- Continuation of source control measures as administered through the State of Utah Groundwater Protection Program.

- Prevent human exposure to unacceptably high concentrations of hazardous substances and/or pollutants or contaminants by limiting access to the contaminated groundwater. Institutional controls include purchases of land, purchases of water rights, limiting drilling of new wells and increased pumping of nearby old wells as approved (on request) and administered through the State of Utah State Engineer (Division of Water Rights).

- Prevent human exposure to unacceptably high concentrations of hazardous substances and/or pollutants or contaminants through point-of-use management which includes providing in-house treatment units to residents with impacted wells, replacement of their water by hooking the properties up to municipal drinking and/or secondary supplies, and/or modifying their wells to reach uncontaminated waters.

- Contain the acid plume in Zone A by installation of barrier wells at the leading edge of the contamination (1500 ppm sulfate or less), pump and treat the waters to provide a hydraulic barrier to further plume movement while providing treated water for municipal use. The treatment technology for the barrier well waters is reverse osmosis.

- Withdraw the heavily contaminated waters from the core of the acid plume in Zone A and treat these contaminated waters using pretreatment with nanofiltration or equivalent technology, followed by treatment with reverse osmosis to provide drinking quality water for municipal use.[1]

- Monitor the plume to follow the progress of natural attenuation for the portions of the Zone A plume which contain sulfate in excess of the state primary drinking water standard for sulfate (500 ppm sulfate).

[1] The RD elects to not implement nanofiltration technology as part of the treatment program. Rather, the acid groundwater will be neutralized in the tailings line (equivalent technology) and supplemented with lime if necessary. The reverse osmosis treatment system will be used to treat sulfate-contaminated water to produce drinking water.

- Disposal of treatment concentrates in existing pipeline used to slurry tailings to a tailings impoundment prior to mine closure.

- Development of a post-mine closure plan to handle treatment residuals for use when the mine and mill are no longer operating.

1.4 Overview of Implementation

1.4.1 Technical Approach

The selected remedy described in Section 1.3 will be organized into three functional units; 1) containment and extraction of contaminated groundwater, 2) treatment of sulfate contaminated water in the Zone A Reverse Osmosis (RO) facility to produce municipal quality water, and 3) neutralization of acidic groundwater in the tailings line using the naturally occurring neutralization potential of the tails (supplemental lime will be added to the tails if necessary). The purpose, scope and objectives for each of these functional units are detailed in Section 3.0.

1.4.2 Updated Failure Modes and Effects Analysis (FMEA)

As with most CERCLA actions, the RI/FS phase did not produce all the data needed for the Remedial Design. To determine the sorts of information needs that are most critical to successful performance of the selected remedy, KUCC consulted its design team to identify gaps in support information and underlying data. In addition, KUCC elected to use a style of engineering risk assessment called "Failure Modes and Effects Analysis" (FMEA). FMEA is a qualitative evaluation that uses experienced specialists to describe an engineered system in terms of its critical components. Using this description of the system and its components, the specialists then systematically identify (a) ways in which adverse effects could arise; (b) the severity of the consequence(s) of those effects; and (c) how the project could mitigate the adverse effects.

The FMEA process allows the project team to concentrate on the information needed to control risk in the components and the overall system. It provides a traceable rationale for the identification of data needs, and therefore for the studies and projects needed to resolve the remaining uncertainties. Preliminary FMEA evaluations were presented in the Remedial Design Work Plan (KUC, 2001). Current status of the FMEA for this project is summarized in Table 1-1, and the results of this evaluation were used to establish the Final Design described in Section 3.0 below. The FMEA process will continue through the rest of the Remedial Action based on monitoring data, and may be used, in conjunction with the monitoring to guide additional actions.

Table 1-1. Summary of Failure Modes and Effects Analysis

FAILURE MODE	ADVERSE EFFECT	RANK OF CONSEQUENCE	POSSIBLE MITIGATION
Groundwater Collection and Containment System			
Well Casing Fails Above Plume	Acidic or high-SO_4 water flows to vadose zone and re-infiltrates Extraction rate compromised	<u>Low</u> to <u>Moderate</u>, depending on amount of flow lost	1. Plug and redrill well 2. Sleeve well
Extraction rate does not contain plume	Plume is not contained; water quality degrades downgradient	<u>High</u> to <u>Extreme</u>	1. Reconfigure pumping 2. Increase extraction rates 3. Install and pump additional wells 4. Add injection wells to improve containment
Extraction rate creates overdraft on aquifer	Rate of water-level decline exceeds State Engineer's guidelines	<u>Moderate</u> (e.g., adjust pumping rates) to <u>Severe</u> (e.g., adverse impacts to water rights or ground subsidence)	1. Monitor water levels against predictions and adjust pumping as necessary; 2. Respond to direction from State Engineer 3. Add injection wells to improve containment
Delivery pipeline fails (acid plume water)	Contaminated water spills to surface Extraction rate compromised	<u>Low</u> to <u>Moderate</u>, depending on volume and period of interruption	1. Place pipelines above ground for inspection 2. Monitor flow rates and shut down flow automatically if rate falls out of acceptable range 3. Double-wall (or otherwise contain) pipelines 4. Leak detection in double-wall, with failsafe 5. Storage during repairs or shut down pumping
Delivery pipeline fails (sulfate plume water)	Contaminated water spills to surface Delivery rate to water treatment (RO units) is compromised	<u>Low</u> to <u>Moderate</u>, depending on volume and period of interruption	1. Place pipelines above ground for inspection 2. Monitor flow rates and shut down flow automatically if rate falls out of acceptable range 4. Storage during repairs or shut down pumping 5. Shut down treatment facility until pipeline is repaired

FAILURE MODE	ADVERSE EFFECT	RANK OF CONSEQUENCE	POSSIBLE MITIGATION
Water Treatment (RO) and Hydraulic Delivery Systems			
Larger volumes than anticipated require treatment and distribution	Capacity must be increased Rate of aquifer clean-up compromised	Moderate to High, depending on scale of modification to schedule	1. Add additional treatment and/or delivery capacity 2. Add additional distribution capacity
Quality of extracted water degrades beyond requirements of RO feed water	Increased feed pressure Lower permeate recovery and quality	Low (technical) to Moderate (cost)	1. Blend with low-TDS water 2. Use nanofiltration or other pretreatment
Concentrate pipeline fails	Contaminated water spills to surface Delivery rate to Copperton tailings line compromised	Low	1. Place pipelines above ground for inspection 2. Monitor flow rates and shut down flow automatically if rate falls out of acceptable range 3. Provide temporary storage (e.g., Desilting Basin) while pipeline is repaired 4. Shut down treatment facilities until pipeline is repaired
Permeate pipeline fails	Clean water delivery interrupted Regulatory impact for drinking water supplies	Low to Moderate	1. Restore flow 2. Provide alternative fresh water through purchase or alternative source

FAILURE MODE	ADVERSE EFFECT	RANK OF CONSEQUENCE	POSSIBLE MITIGATION
Management of Acidic Flows & RO Concentrates in KUCC Tailings Circuit			
Mechanical failure of tailings pipeline	Contaminated water and solids spill to surface Groundwater extraction and treatment rates compromised; Copper production curtailed	Low to High, depending on volume and period of interruption	1. Inspect and maintain 2. Monitor flow rates and shut down flow automatically if rate falls out of acceptable range [Very difficult technically] 3. Store concentrates (e.g., in Desilting Basin) until tailings flow restored 4. Shut down treatment facilities until pipeline is repaired
Pipeline scale affects performance	Scale adversely affects pipeline performance or maintenance schedule	Low (technical) to Moderate (cost)	Control scale by chemical management or physical removal
Design-basis lime (CaO) amendment does not adequately control chemistry in tails	Chemistry of decant pool exceeds discharge criteria Chemistry of return flow exceeds processing criteria	High	1. Increase CaO dosage 2. Control discharge of WDPS, if a short-term problem 3. Treat decant pool, if a short-term problem 4. Adjust chemistry of process-water, if a short-term problem 5. Blend with gray water (or other waters) 6. Long-term mitigation through lime treatment / high-density sludge system
Metals and metalloids not irreversibly removed in tailings solids	Adverse water-quality impacts to discharge	Low (if reversibility is low) to High	1. Control pH of pipeline system to a value that produces stable solids 2. Amend tailing (e.g., with limestone) to control pH in tailing.

FAILURE MODE	ADVERSE EFFECT	RANK OF CONSEQUENCE	POSSIBLE MITIGATION
Management of Acidic Flows and RO Concentrates in KUCC Tailings Circuit (continued.)			
Tailings acidified	Adverse water quality impacts to groundwater and surface water discharge Adverse impacts to surface reclamation Regulatory & permitting impacts	<u>Moderate</u> (if acidity, metals fluxes are low) to <u>High</u>	1. Add sufficient CaO (or other alkaline amendment) in tailing line to provide excess Net Neutralization Potential in tailing 2. Amend tailing in-situ (e.g., with limestone) to provide additional alkalinity in oxidation zone 3. Re-vegetate with resistant species and soil amendments to control phytotoxicity
Water quality not suitable for discharge to GSL at end of mining	Alternative for water and chemical management required	<u>Moderate</u> (if flow volumes and chemistry are moderate) to <u>High</u>	1. Evaporation with "RCRA" containment for solids 2. "Land application", if concentrations do not exceed regulatory limits

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The overall organization of the project team for the Remedial Action and the project's relationship to EPA and UDEQ oversight is shown in Figure 2-1. The specific responsibilities of each individual or group are discussed below.

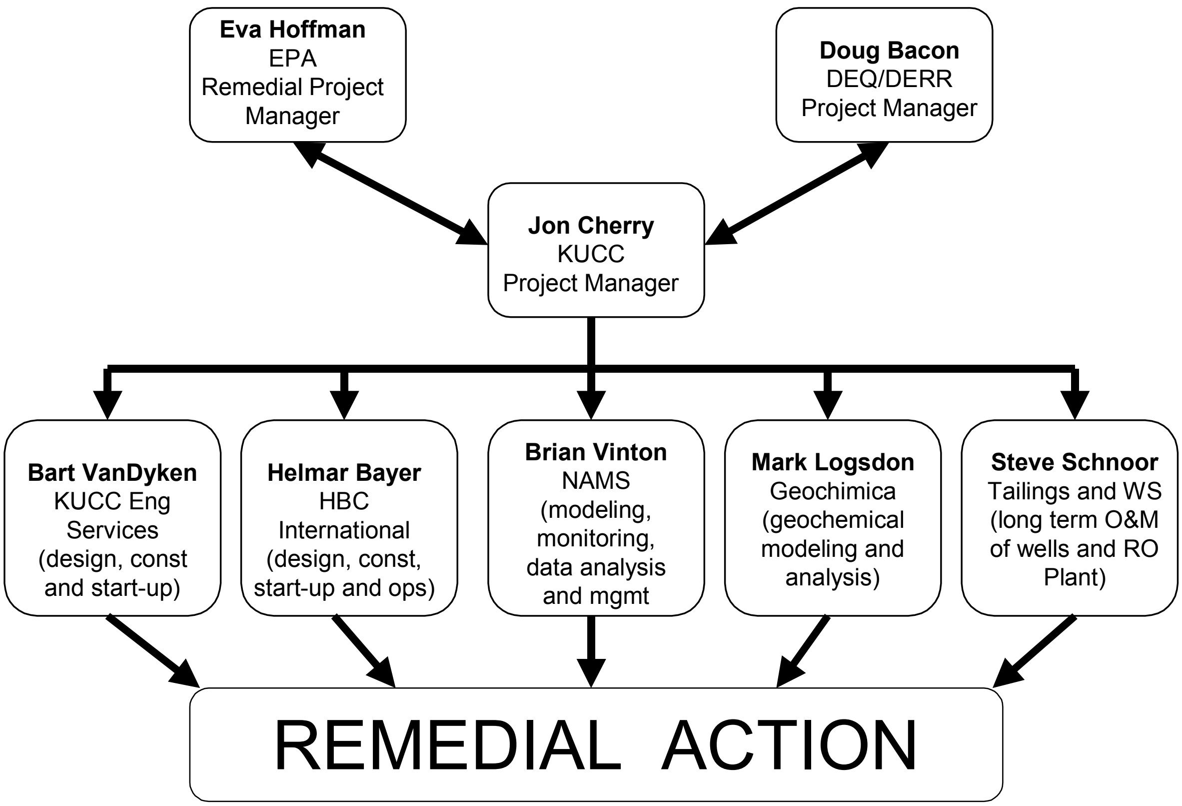
2.1 KUCC Personnel

Mr. Jon Cherry, P.E., is the KUCC Project Manager and main point of contact for communications to and from KUCC. Mr. Cherry is designated as the Design Professional for this program. Mr. Cherry will be responsible for day-to-day communication with the EPA and UDEQ oversight as well as with contractors and consultants hired for specific tasks. His general responsibilities include implementation of a remedial action that will meet the performance criteria specified in the December 13, 2000 Record of Decision (ROD). As project manager, Mr. Cherry will define and clarify the scope of work and objectives for each major activity, and ensure the technical, budget, permitting and schedule requirements are met. Mr. Cherry is a registered professional engineer with over eleven years of RCRA, CERCLA, SARA, and environmental permitting and compliance experience.

Mr. Bart Van Dyken is the KUCC Director of Engineering Services and will oversee the design, construction and start-up of the extraction and treatment facilities. He will be responsible for coordinating the necessary resources to accomplish the design and construction of the various elements and to complete the remedial action phase on schedule. Mr. Van Dyken and his staff will be responsible for the design, documentation, procurement, accounting and construction management of: 1) containment/extraction wells, 2) delivery of the extracted water to the membrane filtration treatment plant(s) and 3) delivery of the treated waters and concentrate streams to water suppliers and the tailings line, respectively. Mr. Van Dyken has over 25 years of engineering experience in large-scale production and environmental remediation projects.

REMEDIAL ACTION ORGANIZATION PLAN

Figure 2-1



Mr. Steve Schnoor, KUCC Tailings and Water Services, will be responsible for the long-term operation and maintenance of the extraction wells, pumps and Zone A Reverse Osmosis Plant. Mr. Schnoor and his staff of operators will be responsible for operating and maintaining the extraction wells and pumps such that the acid and sulfate plumes are contained as required and that the requisite amount of extracted water is delivered to the Zone RO Plant to produce the required volume of drinking water. Mr. Schnoor's team will also be responsible for operating the Zone A RO Plant at the necessary operating configuration to produce 3500 acre-feet per year of drinking water.

2.2 Consultants/Contractors

Mr. Helmar Bayer is the President of HBC International, Inc. and has contracted to KUCC for the past 10 years for treatability testing and design of the membrane treatment plant(s). Mr. Bayer will continue in this capacity, working directly with KUCC Engineering Services, to design, construct and start-up the treatment facilities. Mr. Bayer holds an M.S. in food and fermentation technology and has over ten years experience in wastewater treatment design.

Mr. Mark Logsdon is principal geochemist and President of Geochimica, Inc. and has contracted to KUCC to perform specific geochemical investigations related to the remedial design as well as provide other technical oversight throughout the remedial design process. Mr. Logsdon holds a M.S. in geology with specialization in geochemistry, has published numerous articles on specific geochemical issues and is a recognized expert in his field, with more than 25 years experience in mining-related geochemical studies. Mr. Logsdon will be consulted on an as needed basis to review long term geochemical monitoring in the aquifer and tailings impoundment.

Mr. Brian Vinton is President of North American Mine Services (NAMS). Mr. Vinton and his staff of engineers and technicians have contracted to KUCC over the past ten years for source removal/control projects and the RIFS. Mr. Vinton holds a B.S. in earth science and has over 20 years of experience in the exploration, mining and environmental remediation fields. NAMS is contracted to KUCC as part of the remedial design project to provide technical review, GIS support, groundwater modeling, groundwater monitoring, groundwater data management and source control evaluation.

2.3 Government Oversight: EPA/UDEQ

Dr. Eva Hoffman is the Remedial Project Manager (RPM) from EPA Region VIII for the remedial action. Dr. Hoffman has been the EPA lead project manager for this project during the source removal/control projects and RIFS and will be responsible for coordination of all oversight for the project from EPA's perspective. She also will be responsible for contracting technical support and review from the U.S. Army Corps of Engineers and United State Geological Survey (USGS) to support her oversight role. Dr. Hoffman's responsibilities include ensuring that the remedial action will meet the performance criteria established in the ROD, that the public's interests are protected and that all federal administrative requirements are met.

Mr. Doug Bacon is the lead Project Manager from the State of Utah Department of Environmental Quality (UDEQ) for the remedial action phase of this project. Mr. Bacon was the lead project manager for UDEQ during the FS and ROD. Mr. Bacon will be responsible for coordination of all oversight for the project from UDEQ's perspective and ensuring that all State administrative requirements are met.

2.4 Technical Review Committee (TRC)

The TRC was formed during the initial stages of the RI and has continued through the FS, Remedial Design (RD) and into the remedial action (RA). The committee is comprised of representatives from KUCC, various federal, state and local government agencies, as well as, representatives from local municipalities and local residents. The TRC is co-chaired by the KUCC, EPA and UDEQ project managers. There are two purposes of the TRC. First, the TRC provides a forum in which the technical details and progress of the remedial action can be communicated in a transparent process that allows open dialog between the interested parties. The second purpose of the TRC is to provide technical review in their respective areas of expertise to ensure that basic assumptions are credible and that critical details are not overlooked. Table 2-1 is the current listing of TRC members, their affiliation, phone number and email address.

Table 2-1. South Facilities Technical Review Committee

	NAME	AFFILIATION	PHONE NUMBER	EMAIL
1	Eva Hoffman	EPA	303-312-6764	Hoffman.eva@epamail.epa.gov
2	Helen Dawson	EPA	303-312-7841	Dawson.helen@epamail.epa.gov
3	Joy Emory	FOGSL	801-532-2771	joyemory@hotmail.com
4	Michelle Baguley	HRRR	801-254-4921	Mbaglady@hotmail.com
5	Richard Bay	JVWCD	801-565-8903	RichardB@jvwcd.org
6	Mark Atencio	JVWCD	801-565-8903	MarkA@jvwcd.org
7	Alan Packard	JVWCD	801-565-8903	alanp@jvwcd.org
8	Ryan Evans	KUCC	801-569-6961	Krevans@Kennecott.com
9	Paula Doughty	KUCC	801-569-7120	Doughtyp@Kennecott.com
10	Jon Cherry	KUCC	801-252-3126	Cherryj@Kennecott.com
11	Helmar Bayer	KUCC – HBC Int.	801-569-7301	Khbayer@Kennecott.com
12	Mark Logsdon	KUCC-Geochimica	805-640-8697	Mark.logsdon@sbcglobal.net
13	Brian Vinton	KUCC-NAMS	801-569-7887	Kbvinton@Kennecott.com
14	Mary Pat Buckman	SL Co. Health Dept.	801-313-6707	Mbuckman@eh.co.slc.ut.us
15	Steve Noble	South Jordan City	801-253-5230	Snoble@Sjordan.state.ut.us
16	Frank Roberts	UDEQ – DDW	801-536-0098	froberts@deq.state.ut.us
17	Brent Everett	UDEQ – DERR	801-536-4171	Beverett@deq.state.ut.us
18	Doug Bacon	UDEQ – DERR	801-536-4282	Dbacon@deq.state.ut.us
19	Doug Taylor	UDEQ – DSHW	801-538-6857	Dtaylor@deq.state.ut.us
20	Dennis Frederick	UDEQ – DWQ	801-538-6038	Dfrederick@deq.state.ut.us
21	Dan Hall	UDEQ – DWQ	801-538-9153	Dhall@deq.state.ut.us
22	Bill Moellmer	UDEQ – DWQ	801-538-6329	Wmoellme@deq.state.ut.us
23	Tom Munson	UDNR – DOGM	801-538-5321	Nrogm.tmunson@state.ut.us
24	Karl Kappe	UDNR – GSL	801 538-5273	Nrslf.kkappe@state.ut.us
25	Chuck Williamson	UDNR – Water Rights	801-538-7392	Nrwrt.cwilliam@state.ut.us
26	Jared Manning	UDNR – Water Rights	801-538-7455	Nrwrt.jmanning@state.ut.us
27	Mark Wichman	USACE - Omaha	402-221-4135	Mark.d.wichman@usace.army.mil
28	Bert Stolp	USGS	801-908-5061	Bjstolp@usgs.gov
29	Roger Payne	West Jordan City	801-569-5761	RogerP@Wjordan.com
30	Scott Hill	Riverton City	801-253-4145	na
31	Kim Shelley	DWQ	801-538-6760	kshelley@utah.gov

(REVISED December 18, 2002)

3.0 FINAL DESIGN

3.1 Purpose, Scope and Objectives of the Final Design

The purpose of the Remedial Design (RD) is to develop and document the technical requirements of the Remedial Action that will be executed by KUCC to resolve the CERCLA issues associated with contamination of groundwater from mining activities. Where appropriate, this design also addresses KUCC's obligations related to the previously mentioned NRD settlement. The general nature of the selected remedy and an overview of the conceptual design for that remedy have been presented in Sections 1.3 and 1.4, above.

The scope of the Final Design includes plans for three "functional units" of the conceptual plan during the period in which the Bingham Canyon mine continues to operate:

- Groundwater containment and extraction system (including monitoring);
- Water treatment (RO) and hydraulic delivery system for treated water and concentrate;
- Management of acid plume water and Zone A RO concentrates in KUCC tailings circuit.

In addition, Appendix A to this Final Design Report describes KUCC's approach to post-mining water management. This appendix has been prepared at the level of a Preliminary Design. The plan for post-mining water management will be updated formally as part of the 5-Year Reviews during Remedial Action. Through the update process, there will be a final engineering design for all aspects of post-mining conditions prior to the actual end of mining act Bingham Canyon, which is expected to be some time between 2013 and 2030, depending on long-term mine planning.

The Final Design addresses processes and designs that will be used by KUCC to meet the terms of the ROD both during operational stages of the mine and after the end of mining. The level of detail for the operational phase is much greater than for the end-of-mining phase, as we expect that much will be learned during the period of expected operation that can be applied in the context of closure but which cannot be anticipated in detail at this time.

This Final Design Report provides the general plans and specifications for a performance-based Remedial Action that would be detailed and executed by KUCC or the selected contractor(s). Objectives of the Final Design include:

- Identify performance and, as appropriate, design criteria for each "functional unit" of the conceptual design;
- Present the results of supplemental testing, sampling and analytical programs executed during the Remedial Design process to address data needs that were identified after the RI/FS;
- Document the performance-based designs in plans and specifications.

The Final Design Report is organized in terms of the three "functional units" discussed below.

3.2 Groundwater Containment and Extraction

Zone A groundwater will be extracted from acid and sulfate contaminant plumes (Figure 3-1). The acid plume contains low pH/high TDS water that will be extracted and routed to the tailings line via the Wastewater Disposal Pump Station (neutralization of the acid water is discussed in Section 3.4). Sulfate water from Zone A will be routed to the RO Plant. The Zone B sulfate groundwater extraction and treatment plan will be implemented by others through various agreements with the State of Utah and local water purveyor(s).

Extraction rates from the Zone A sulfate plume wells will be adjusted to accommodate the feed water requirements at the RO Plant and to produce the required 3500 acre-feet per year of drinking water while containing the sulfate plume at 1500 mg/L on KUCC property. If additional wells are needed to contain the sulfate plume on KUCC property, the average extraction rate would still be in the 2500 to 3500 gpm range with production of 3500 acre feet of drinking water per year. Table 3-1 lists the planned extraction rates and volume for the sulfate and acid extraction wells. Placement of these wells is shown below in Figure 3-2.

3.2.1 Acid Plume Containment and Extraction

Water from the acid wells will be routed to the tailings line via the Wastewater Disposal Pump Station (WDPS). The current acid well, ECG1146, was installed in 1995 along with a pipeline delivery system to the Membrane Filtration Plant (Figure 3-2 and 3-5). A second acid well will be installed approximately ¼ mile east of Highway 111 and adjacent to and south of the Trans Jordan Landfill in late 2002 or early 2003. Additional acid wells will be installed in the future to contain the acid plume. They will be located where the maximum acid-water extraction is likely based on then-current groundwater monitoring and modeling results. The current (December, 2002) extraction rate for ECG1146 is 900 gpm. Routing of flows after extraction is described in Section 3.2.1.2 below.

Optimal containment of the acid plume over the life of the project will be achieved by evaluating the monitoring data described in Section 3.2.3. KUCC will use its calibrated groundwater flow model as a planning tool for ongoing optimization of plume containment and groundwater extraction. The model will be calibrated periodically using data from ongoing monitoring. Extraction rates and well-field geometry will be set according to monitoring results to contain the acid plume, to extract Zone A sulfate waters for treatment to drinking-water standards, to contain the 1500 mg/L sulfate plume on Kennecott property and to balance the hydraulic response of the aquifer (drawdown) with the need to protect the ability of the aquifer to transmit the acid water to the wells.

Figure 3-1 Zone A and Zone B Groundwater Plumes

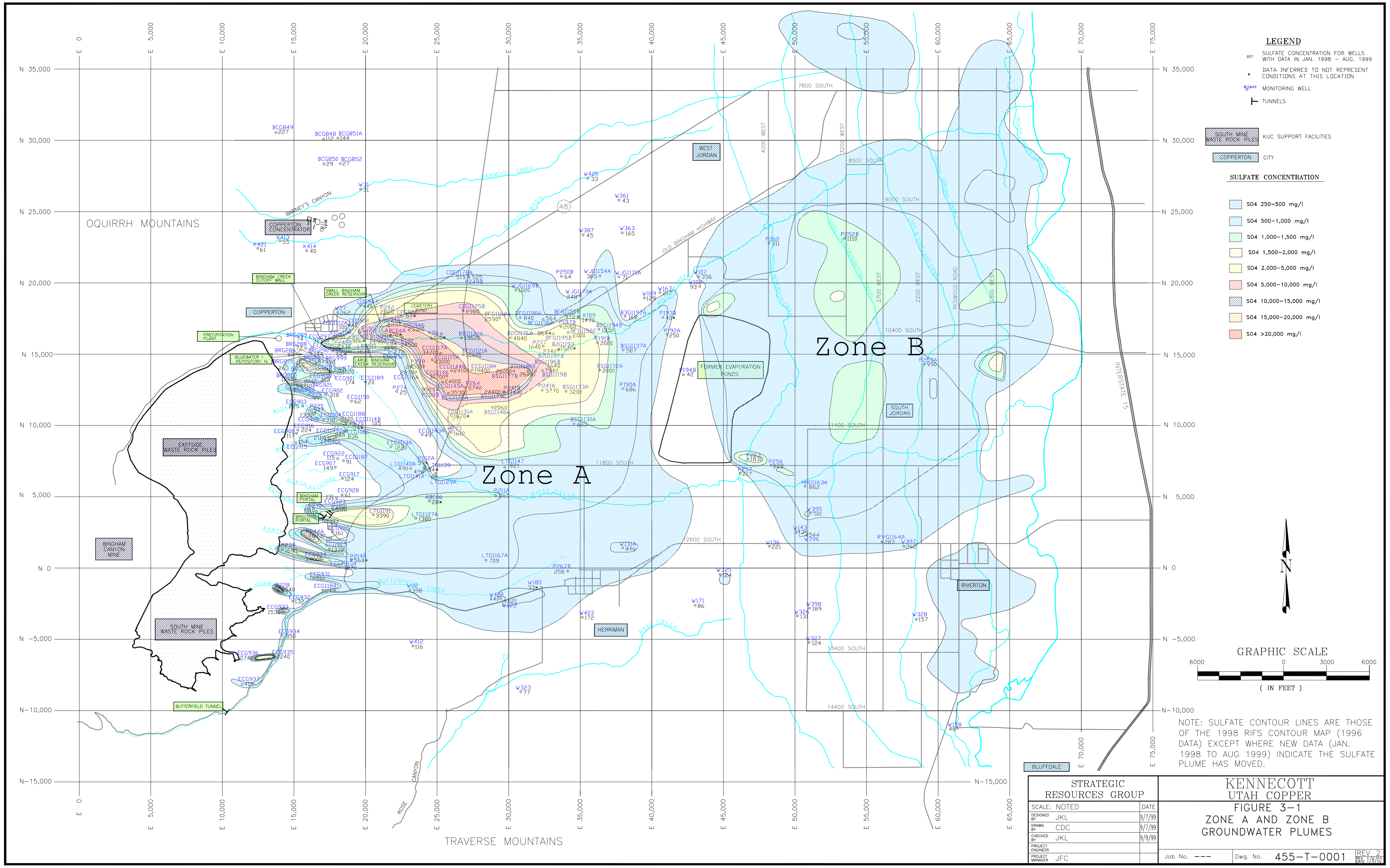


Table 3-1. Extraction Rates for Proposed Remedial Strategy

Well	Model Layer*	Pumping Rate (gpm)	Pumping Rate (as: ac-ft/yr)	Estimated Years[ψ]
Acid Well (ECG1146)	4	750-1500	*(1200-2400)*	0-5
New Acid Well #1	4	Varied[†]	*(Varied[†])*	0-30
New Acid Well #2	4	Varied[††]	*(Varied[††])*	6-50
New Acid Well #3	4 (50%), 5 (50%)	Varied [†††]	*(Varied [†††])*	16-50
BFG1200 (K109)	4, 5, 6	~1100	*(~1750)*	0-50
B2G1193 (K60)	4, 5	~1100	*(~1750)*	0-50
LTG1147	3 (50%), 4 (50%)	~1000	*(~1600)*	0-50

* Layer 3 is approximately 0 – 150 feet below the groundwater table
Layer 4 is approximately 150 – 300 feet below the groundwater table
Layer 5 is approximately 300 – 450 feet below the groundwater table
Layer 6 is approximately 450 – 650 feet below the groundwater table

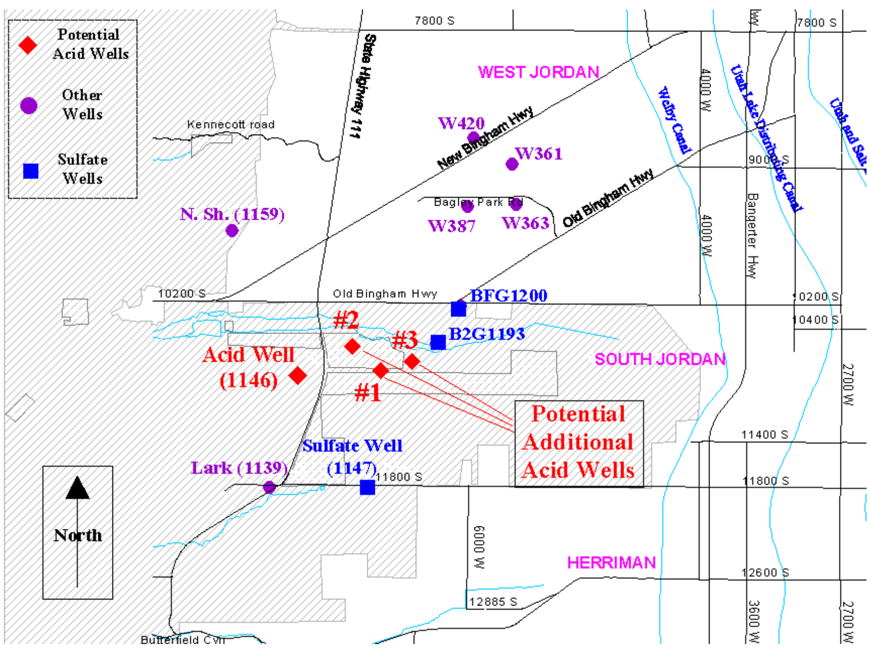
ψ Actual pumping will be evaluated based on water quality and efficiency at this location

† Varied Pumping as necessary: Years 0-15, ~1000 gpm (*1600afy*); Years 16-50, ~500 gpm (*800 afy*)

†† Varied Pumping as necessary: Years 6-15, ~1000 gpm (*1600 afy*); Years 16-50, ~500-750 gpm (*800-1200 afy*)

††† Varied Pumping as necessary: Years 16-30, ~750 gpm (*1200 afy*); Years 31-50, ~500-750 gpm (*800-1200 afy*)

Figure 3-2 Extraction Well Locations



3.2.1.1 Acid Extraction Well Construction

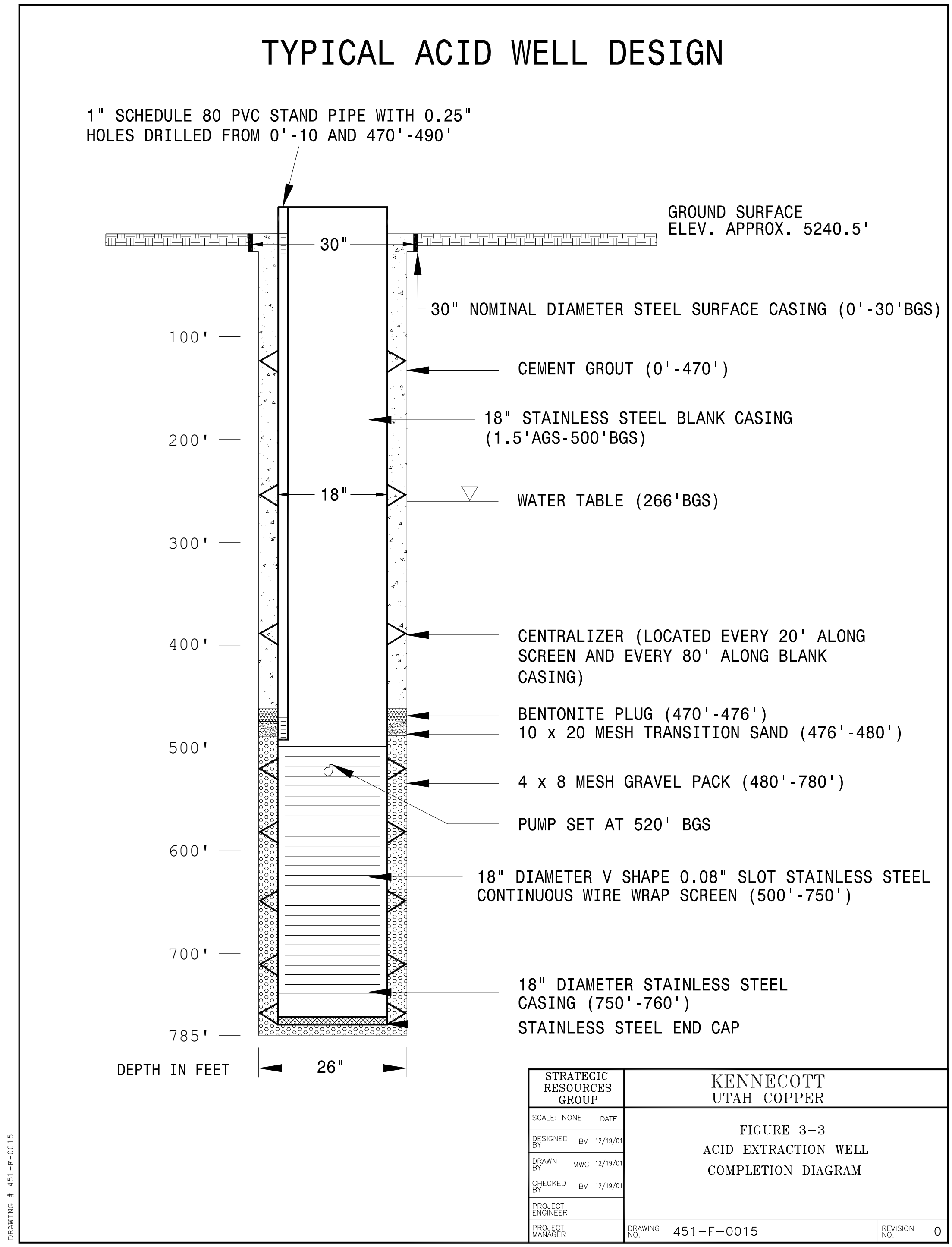
In addition to acid well ECG1146, other acid wells will be drilled and installed in the same manner (Kennecott RI 1998). Typical acid-well design will include an eighteen-inch nominal diameter stainless steel casing and screen (Figure 3-3). A submersible stainless steel pump will be installed at depth within the casing. The well, pump, and appurtenances in contact with low pH water will be stainless steel and designed to withstand the water pumping pressure for each specific well. Screen intervals for all additional wells will include all portions of the aquifer identified during monitoring as containing low pH water (<3.5 pH s.u.).

3.2.1.2 Acid Plume Piping

All of the acid-well water will be piped through a 12-inch to 14-inch HDPE pipe encased in a 16-inch to 18-inch secondary HDPE containment pipe. The current pipeline was designed as such and includes approximately 7500 feet of line from ECG1146 to the Eastside Collection Reservoir (Figures 3-2 and 3-5). The second acid well line will include approximately 4700 feet of line from the planned well site to ECG1146. This line will be sized to facilitate the possibility of maximum volume extraction in the eastern extent of the acid plume. The pipe will be designed to withstand the additional pressure due to its lower elevation location. Each of the respective acid wells will be designed with monitoring devices to ensure proper pump operation, flow metering and depth to water. These devices also will be programmed to shut down the well if any one parameter is not within the tolerance allowed. The secondary containment pipe also will be monitored at each of the down gradient well locations. If any flow is detected in the secondary pipe at any of the acid well sites by the continuous-reading conductance probes, the conductance signal will be conveyed to the electrical circuit at each of the wells, and each well will be programmed to shut down until the problem is identified and repaired.

The current pipeline will be re-routed to the cement-lined canal and/or the Precipitation Plant (P-Plant). Flow in the cement-lined canal will report to the WDPS that delivers water to the beginning of the tailings line. If the WDPS station needs repair and down time is scheduled, the flow from the acid wells will either be shut down until repairs are complete or be diverted to the Bingham Reservoir. Flow to the P-Plant will either be pumped to HDPE-lined evaporation ponds on the Eastside Waste Rock dumps during the summer months or routed to the WDPS or the Bingham Reservoir. The second acid well pipeline will be tied into the pipeline adjacent well ECG1146. Any additional pipelines from future acid wells will also be tied to the pipeline from well ECG1146. The existing pipeline from ECG1146 to the lower cement-lined canal has the capacity to carry up to 3000 gpm.

Figure 3-3 Typical Acid Extraction Well Design



3.2.2 Sulfate plume Containment and Extraction (Zone A)

Water from the sulfate wells in Zone A will be routed to the RO Plants as described in Section 3.3. The wells include LTG1147 (sulfate well), B2G1193 (K60) and BFG1200 (K109). Each of the three wells has existing conveyance lines which will be re-routed directly to the RO Plant. The flow from each well will be regulated by two objectives: (a) to contain the 1500 mg/L sulfate plume on KUCC property and (b) to provide a composite flow that will satisfy the water-quality and quantity requirements of the RO Plant. The current well-field configuration meets these requirements, based on the operations data for pilot-testing the RO Plant over time since 1996. If monitoring and its evaluation through groundwater-flow modeling reveal that additional wells are needed to contain the Zone A sulfate plume, KUCC will develop and submit for approval plans and specifications that are similar to those for the existing well sites. The plan would include supporting monitoring data, drawdown modeling results, and water-quality predictions.

As part of Zone A sulfate containment, KUCC is also evaluating injecting water into a portion of the principal aquifer in the BFG1200/West Jordan Well Field area. Injection would provide additional hydraulic containment for the sulfate plume and also would recharge the overdraft of the principal aquifer that has developed from over-extraction during the last decade or more. Development of a feasibility plan for injection will be evaluated and recommendations completed in 2003.

3.2.2.1 Preliminary Evaluation Report

A Preliminary Evaluation Report (PER) on the feasibility and appropriateness of a particular groundwater source for use as a drinking water source is required under Utah Administrative Codes R309-600, R655-4 and R309-204. A PER and the engineering specifications were submitted and approved by the Division of Drinking Water prior to completion of well BFG1200. Wells B2G1193 and LTG1147 were completed without a PER before details of the Remedial Design were worked out; however, both wells have been discussed with the State, and the State has asked that the information required in the PER be included in the Drinking Water Source Protection Plan (DWSP) for all of the sulfate wells. Any additional sulfate-extraction wells will follow the procedures as defined in the State regulations. All drilling and well construction materials will be in compliance with existing State regulations.

3.2.2.2 Drinking Water Source Protection (DWSP) Plans

All Zone A sulfate wells that are or will be routed to the RO Plant are required by the State to have approved DWSP plans. As agreed with the State, one plan will be completed that will include all three existing sulfate wells. This plan will be completed in 2003.

3.2.2.3 Sulfate Well Construction

Sulfate Well LTG1147 was installed in 1995 (Kennecott RI, 1998) and has been in operation through 2002. B2G1193 was installed in 1997, and BFG1200 was installed in 2000. The typical sulfate-well design includes an eighteen-inch nominal diameter stainless steel screen and a steel casing (Figure 3-4). Each well has a submersible pump, and the combined flow will meet the required volume of 3500 acre feet per year. These wells were originally constructed to supply make-up water to the Copperton concentrator.

3.2.2.4 Sulfate Plume Piping and Routing

Pipelines from current sulfate containment wells currently exist and convey water from the extraction location to the Copperton concentrator. When the Zone A RO Plant construction is complete, these pipelines will be diverted to the plant. Pipeline design and routing can be viewed in Figure 3-5. Each of the lines from the well sites are designed to convey maximum flow from each well. Pipelines are installed per manufacture's instructions.

3.2.3 Groundwater Monitoring

3.2.3.1 Introduction

As part of the Remedial Design/Remedial Action on the CERCLA groundwater plume in the Southwest Jordan Valley, KUCC will monitor the groundwater in and around the contaminant plume. In 2001, a Baseline Groundwater Chemistry and Water Level Study (Appendix D) was conducted to create a representation of the shape and size of the Zone A contaminated groundwater plume at the start of remediation and to document the status of water level changes at the time in the valley. The frequency and intensity of long-term monitoring as discussed in this section is based on the results of that Baseline study and previous Remedial Investigation results.

Future monitoring data will be compared to the baseline representation to evaluate the effectiveness of remediation and its impact on water levels and groundwater quality in the valley. Three types of data will be collected in the course of groundwater monitoring: water level elevation measurements (annual to monthly measurements on 317 wells), groundwater chemistry from well sampling (29 different analytes on samples collected on a semiannual to every two year sampling frequency on samples from 100 wells) and ground surface elevation monitoring (annual survey from 7 different well sites) . Annual monitoring reports completed as part of the Groundwater Characterization and Monitoring Plan will detail significant changes in the plume geometry and chemistry. These reports may include potentiometric maps, potentiometric-change maps, contaminant distribution maps and/or hydrogeologic cross sections. This monitoring plan will be a working plan with flexibility to increase or decrease groundwater-monitoring intensity in response to changes seen in the plume.

3.2.3.2 Purpose

Groundwater monitoring data will be used for several purposes:

1. Monitor the impacts of remedial extraction and natural attenuation on the shape and size of the Zone A contaminant plume. Data will be compared to the pre-remediation (2001) representation of the shape and size of the contaminated groundwater plume created using Baseline Study data.

2. Monitoring results will be used to assure compliance with the stipulations of the Record of Decision for KUCC South Zone Groundwater Plumes (ROD) (EPA and UDEQ, 2000), that is, that groundwater with greater than 1500 mg/L sulfate and/or metals concentrations exceeding state and federal drinking water standards does not migrate outside the area of contamination defined in the Feasibility Study. The ROD also requires the natural attenuation of groundwater with greater than 500 mg/L sulfate be monitored.

Figure 3-4 Typical Sulfate Extraction Well Design